MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2016/2017

EOP2016 – FUNDAMENTALS OF OPTICS

(OPE)

9th MARCH 2017
0900 - 1100
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 6 pages with 3 Questions only.
2. Attempt **THREE** out of **THREE** questions. Distribution of the marks for each question is given.
3. Please print all your answers in the Answer Booklet provided.

Question 1

(a) According to Figure Q1(a), the time needed for light to go from point A to point B is given by

$$t = \left[\left(h_1^2 + y^2\right)^{1/2} + \left(h_2^2 + (w-y)^2\right)^{1/2}\right]$$

Derive the Snell's law of reflection using *Fermat*'s principle.

[4 marks]

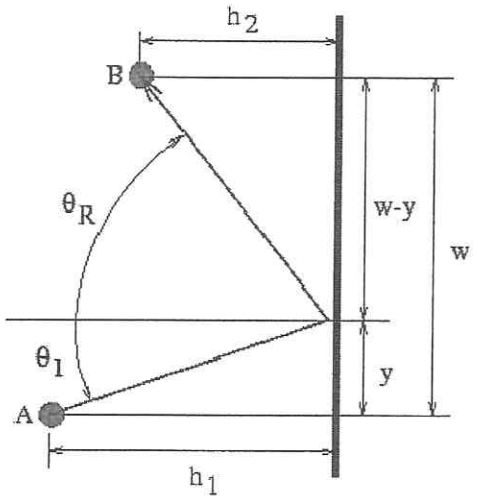

Figure Q1(a)

(b) Describe photon scattering effect (what happen when two photons collide) and photoelectric effect. Explain how these two effects support the photon theory of light. Use a simple sketch to aid your explanation.

[4 marks]

(c) Describe the optical phenomenon that allows light to travel inside an optical fiber. Support your answer with a suitable diagram and relevant formula.

[5 marks]

Continued...

Question 2

(a) Ahmad is 6-ft tall. He would like to buy a wall mirror that will allow him to view his entire height. Calculate the minimum height of that mirror. Sketch rays from the top and bottom of Ahmad, and determine the proper placement of the mirror such that the full image is seen, regardless of Ahmad's distance from the mirror.

[5 marks]

(b) Calculate the focal length of a thin meniscus lens whose spherical surfaces have radii of curvature of magnitude 5 and 10 cm. The glass is of index 1.50.

[6 marks]

(c) A harmonic wave is represented by the following mathematical expression

$$(10\ \text{cm})\sin[2\pi(628.3/\text{cm})x - (6283/\text{s})t]$$

Determine (i) wavelength; (ii) frequency; (iii) propagation constant; (iv) angular frequency and (v) velocity.

[10 marks]

(d) Two coherent light waves of amplitudes 1.8 and 2.6 interfere at some point on a screen. What would be the resulting visibility at that point (i) if their field vectors are parallel and (ii) if they are perpendicular?

[4 marks]

Continued...

Question 3

(a) What is meant by polarized and unpolarized light? Give an example of both.

[4 marks]

(b) Initially unpolarized light passes in turn through three linear polarizers with transmission axes at 0°, 30° and 60°, respectively to the horizontal plane of the polarizers. What is the irradiance of the product light, expressed as a percentage of the unpolarized light irradiance?

[6 marks]

(c) Specify the polarization mode for each of the following Jones vector.

(i) $\begin{bmatrix} 3i \\ i \end{bmatrix}$, (ii) $\begin{bmatrix} i \\ 1 \end{bmatrix}$

[4 marks]

(d) Determine the half-wave voltage for a longitudinal Pockels cell made of ADP ($r=8.56$ pm/V^2 and $n_o = 1.48$) at wavelength of 546 nm.

[2 marks]

(e) Calculate the length of a Kerr cell using carbon disulfide required to produce half-wave retardation for an applied voltage of 30 kV. The electrodes of the cell have a separation of 1.5 cm. Give a comment whether this cell is practical.

[3 marks]

(f) What acoustic frequency is required of a plane acoustic wave, launched in an acousto-optic crystal, so that a He-Ne laser beam is deflected by 1°? The speed of sound in the crystal is 2500 m/s and its refractive index at 632.8nm is 1.6.

[3 marks]

Continued...

Appendix A

Physical Constants and Units

Constant	Symbol	Value (mks units)
Speed of light in vacuum	c	3×10^{8} m/s
Electron charge	q	1.602×10^{-19} C
Boltzmann's constant	k_B	1.38×10^{-23} J/K
Permittivity of free space	ε_0	8.8542×10^{-12} F/m
Permeability of free space	μ_0	$4\pi \times 10^{-7}$ N/A^2
Electron volt	eV	1 eV = 1.602×10^{-19} J
Planck's constant	h	6.626×10^{-34} J·s

Summary of Jones Matrices

I. Linear polarizers

TA horizontal $\begin{bmatrix}1 & 0\\ 0 & 0\end{bmatrix}$ TA vertical $\begin{bmatrix}0 & 0\\ 0 & 1\end{bmatrix}$ TA at 45° to horizontal $\frac{1}{2}\begin{bmatrix}1 & 1\\ 1 & 1\end{bmatrix}$

II. Phase retarders

General $\begin{bmatrix}e^{i\varepsilon_x} & 0\\ 0 & e^{i\varepsilon_y}\end{bmatrix}$

QWP, SA vertical $e^{-i\pi/4}\begin{bmatrix}1 & 0\\ 0 & i\end{bmatrix}$ QWP, SA horizontal $e^{i\pi/4}\begin{bmatrix}1 & 0\\ 0 & -i\end{bmatrix}$

HWP, SA vertical $e^{-i\pi/2}\begin{bmatrix}1 & 0\\ 0 & -1\end{bmatrix}$ HWP, SA horizontal $e^{i\pi/2}\begin{bmatrix}1 & 0\\ 0 & -1\end{bmatrix}$

III. Rotator

Rotator $(\theta \rightarrow \theta + \beta)$ $\begin{bmatrix}\cos\beta & -\sin\beta\\ \sin\beta & \cos\beta\end{bmatrix}$

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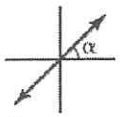
Summary of Jones Vectors

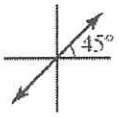
I. Linear Polarization ($\Delta\varphi = m\pi$)

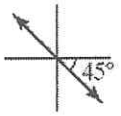
General: 

$$\tilde{\mathbf{E}}_0 = \begin{bmatrix} \cos\alpha \\ \sin\alpha \end{bmatrix}$$

Vertical: $\tilde{\mathbf{E}}_0 = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$

Horizontal: $\tilde{\mathbf{E}}_0 = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$

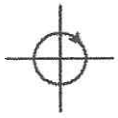
At $+45°$: $\tilde{\mathbf{E}}_0 = \frac{1}{\sqrt{2}}\begin{bmatrix} 1 \\ 1 \end{bmatrix}$ 

At $-45°$: $\tilde{\mathbf{E}}_0 = \frac{1}{\sqrt{2}}\begin{bmatrix} 1 \\ -1 \end{bmatrix}$ 

II. Circular Polarization $\left(\Delta\phi = \frac{\pi}{2}\right)$

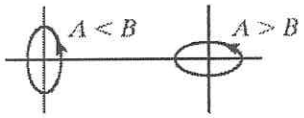
Left:

$$\tilde{\mathbf{E}}_0 = \frac{1}{\sqrt{2}}\begin{bmatrix} 1 \\ i \end{bmatrix}$$

Right: 

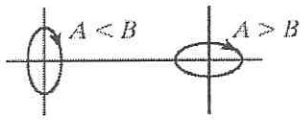
$$\tilde{\mathbf{E}}_0 = \frac{1}{\sqrt{2}}\begin{bmatrix} 1 \\ -i \end{bmatrix}$$

III. Elliptical Polarization

Left: 

$$\tilde{\mathbf{E}}_0 = \frac{1}{\sqrt{A^2 + B^2}}\begin{bmatrix} A \\ iB \end{bmatrix} \quad A > 0, B > 0$$

$(\Delta\phi = (m + 1/2)\,\pi)$

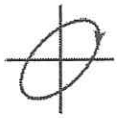
Right: 

$$\tilde{\mathbf{E}}_0 = \frac{1}{\sqrt{A^2 + B^2}}\begin{bmatrix} A \\ -iB \end{bmatrix} \quad A > 0, B > 0$$

Left:

$$\tilde{\mathbf{E}}_0 = \frac{1}{\sqrt{A^2 + B^2 + C^2}}\begin{bmatrix} A \\ B + iC \end{bmatrix} \quad A > 0, C > 0$$

$\left(\Delta\phi \neq \begin{cases} m\pi \\ (m + 1/2)\pi \end{cases}\right)$

Right: 

$$\tilde{\mathbf{E}}_0 = \frac{1}{\sqrt{A^2 + B^2 + C^2}}\begin{bmatrix} A \\ B - iC \end{bmatrix} \quad A > 0, C > 0$$

End of paper.